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Changing towards electric vehicle use in Greater Stockholm

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This paper studies electric vehicle (EV) adoption in Greater Stockholm in Sweden using the Transtheoretical Model of Change (TTM) and the Protection Motivation Theory as a framework and considers socio-cognitive, behavioural and socio-economic attributes that may influence the process towards electric vehicle use. TTM considers behavioural change as a process consisting of five stages-of-change rather than as an event. Some key findings were made: (1) from the earlier to the later stages-of-change, the attitude towards EVs becomes more positive, the knowledge about EVs increases and the self-efficacy is consistently increasing. (2) The threat appraisal and response efficacy of EVs increase from stage to stage in the stages prior to the actual change but have a lower level for the stages after the change. (3) The explanatory power of regression models modelling both pre-contemplation and all stages-of-change increases significantly when incorporating socio-cognitive variables such as self-efficacy, threat-appraisal, response efficacy and attitudes towards EVs. (4) The modal share of the car is consistently increasing throughout the stages-of-change. The results indicate that policy measures aiming at increasing knowledge and self-efficacy of car drivers related to EV use can stimulate electric vehicle adoption. Also, the relative advantages of EVs for car drivers should get more attention rather than only emphasizing the environmental advantages.

Keywords: *electric vehicle adoption, Transtheoretical Model of Change, Protection Motivation Theory.*

1. Introduction

The transport sector is responsible for a considerable percentage of global anthropogenic greenhouse gas emissions, which are likely to have an effect on the process of climate change (Gardner et al., 2013). Besides that, local emissions from transport have substantial negative health effects on the people living close to large transport infrastructure (Dons et al., 2014). When striving to achieve a more sustainable transport system, a common strategy by policy makers is

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to influence the use of the transport system and reduce its dependency on fossil fuels. One component of such a strategy can be to encourage the adoption of electric vehicles.

Electric vehicles (hereafter EVs), while showing promise for reducing transport-related emissions and dependence on fossil fuels, are today only in limited use in most countries around the world and the variations between different countries are considerable (Nykvist and Nilsson, 2015). There are several factors that seem to mediate the uptake of EVs. Firstly, the current average EV has a limited range and it takes much more time to charge an electric vehicle than to refuel conventional vehicles. Secondly, EVs have a much higher upfront price than comparable conventional vehicles.

Because of these (perceived) range and cost issues, EV adoption does not just happen and in many countries, different policy measures have been implemented in order to stimulate the purchase of EVs. These policy measures can make EVs more attractive. However, if they are directed towards car users that are unlikely to respond, they can be ineffective. Different people have different needs and preferences, thus they have a different appreciation and a different learning process in adopting new choices and technology (e.g. Anable, 2005).

In previous research investigating electric vehicle adoption, different aspects have been identified that stimulate or hamper electric vehicle adoption, dealing with instrumental, hedonic and symbolic aspects (e.g. Carley et al., 2013; Axsen and Kurani, 2013; Skippon and Garwood, 2011; Lopes et al., 2011; Noppers et al., 2015 & Schuitema et al., 2013). However, much is still unknown about the developments during the process towards electric vehicle adoption. Klöckner (2014) has investigated the process towards electric vehicle adoption, but that study is limited in scope regarding current electric vehicle users. Also, this study did only include people that are interested in purchasing EVs. In the Background Section, a more extensive description of this study will follow.

People that are in different stages of the process of behavioural change towards electric vehicle use might respond differently to policy incentives. Therefore, more insight into this process is needed. This paper contributes to the existing literature by investigating this process of change and how socio-cognitive, behavioural and socio-economic characteristics differ between people being in different stages-of-change. Following this structure allows comparing variables that are important for specific stages. Also, it allows modelling how the values of the independent variables differ from stage to stage. Thirdly, it allows exploring which independent variables, amongst others constructs of the Protection Motivation Theory (PMT), have an influence on propensity to be in a specific stage-of-change.

Thus, the aim of this study is to explore the relation between attitudinal, behavioural and socio-economic characteristics and the stage-of-change towards EV use, making use of the Transtheoretical Model of Change (TTM) and the Protection Motivation Theory (PMT). These models will be explained below. In this research, the approach of investigating socio-economic, behavioural and socio-cognitive variables is combined with considering the change towards EV use as a process that follows different stages.

In this study, the behavioural changes of active drivers in Greater Stockholm are investigated. In the next Section, the background of electric vehicle adoption studies is described. After that, a short introduction of EV adoption in the study area (Greater Stockholm) is provided, followed by the theoretical framework of this study. After that, the data collection process is described, followed by the results of the statistical analyses. The discussion and conclusion sections form the final sections of this paper.

2. Background

Electric vehicles have a higher upfront price and their limited range is widely considered to be a problem hampering large-scale deployment (e.g. Carley et al., 2013). In order to investigate electric vehicle adoption, much research has been done aiming at quantifying these range and price problems. Axsen and Kurani (2013) studied the willingness to adopt HEVs, PHEVs and BEVs and concluded that only a few per cent of potential car buyers would consider buying a BEV. Major concerns were both range limitations and the price premium that has to be paid for BEVs. Several studies have made estimations about how much range is needed to accommodate the daily travel needs of different percentages of the current car market. For example, Pearre at al. (2011) studied travel patterns of a sample of 484 drivers in the US and concluded that 9 per cent of the sample never exceeded 160 kilometres per day, while 21 per cent never exceeded 240 kilometres per day. EVs with a range of 240 kilometres could therefore be adopted by around 21 per cent of the car drivers without the need for behavioural adaptations. If, however, people would be willing to make behavioural adaptations 6 times a year, an EV with a range of 160 kilometres could accommodate 32 per cent of the car drivers. Also Skippon and Garwood (2011) concluded that mainstream consumers need at least 240 kilometres of range to start considering EVs as their main vehicle. This contrasts with an early study about stated behavioural adaptations as a result of electric vehicle use concluding that many households are quite flexible in changing their travel patterns when facing range limitations of electric vehicles (Kurani et al., 1994).

Electric vehicles have a different cost structure than internal combustion engine vehicles. The upfront costs are higher, but the operational costs are typically much lower. Regarding cost premiums, Skippon and Garwood (2011) found that consumers were willing to pay a premium for purchasing an EV similar to three years fuel cost savings because of EV-use. In order to make an assessment of the cost in comparison to the cost of ICEVs, the Total Cost of Ownership should be considered (e.g. Hagman et al., 2016). Considering the Total Cost of Ownership, EVs might be cheaper over the course of the lifetime of the car, especially in case the vehicle is frequently used and in case electricity prices are relatively low. In Hagman et al. (2016), policy incentives have been included in the assessment of the Total Cost of Ownership. However, relatively few consumers make these calculations, and most consumers concentrate on the high investment costs.

In many countries, policy measures are taken to stimulate the purchase of EVs. These policy measures include: upfront subsidies, tax deductions or other benefits like free EV charging in public space, free parking or free use of bus lanes and toll roads (Bakker and Trip, 2013). Compared to other countries, Norway has seen a relatively fast adoption of EVs. Norway also provides a large package of policy measures such as upfront-subsidies, free parking, toll exemption and free use of ferries (Figenbaum and Kolbenstvedt, 2013). Most 'EV pioneers', the first car drivers purchasing an electric vehicle, have thus been buying their vehicle in an environment full of policy measures that may have influenced their decision to purchase an EV, being stimulated to "do the right thing" and buy an EV. However, the adoption of EVs should not be seen in isolation from the other aspects of sustainable mobility, which is one of the ambitions of the European Union and has been translated into the so-called Sustainable Urban Mobility Plans (SUMP) (European Commission, 2013). Changing from conventional vehicles to EVs is one strategy of improving the sustainability of the transport system, but despite the absence of tailpipe emissions, the energy use of EVs can still be considerable, even though EVs are more energy efficient than conventional vehicles. The electricity might be generated using power plants that emit large amounts of exhaust gases (e.g. Calnan et al., 2013). Although EVs are quieter than conventional vehicles, they still need a large part of public space which is scarce, particularly in urban areas. Congestion problems and parking issues will not be solved by changing the entire vehicle fleet to electric vehicles and the effects of the electrification of the vehicle fleet on traffic safety is still unclear (Cocron and Krems, 2013).

The motivations for EV adoption by individual car drivers may differ from the reasons why policy makers want to stimulate the adoption of EVs (namely environmental concerns). This may, in turn, influence new behaviours when using an EV. Therefore, more insight should be gained into the reasons for adopting EVs and more focus should be on the potential EV-user.

Until now, electric vehicle adoption has often been investigated by formulating potential EV users as users whose socio-economic characteristics and travel patterns are "EV-compatible" (e.g. Lopes et al., 2014), following the reasoning that cost and range are the most important issues. However, EV-adopters are currently only a very small subset of this group of EV-compatible car drivers and might even contain people that are not considered to be EV-compatible. Besides instrumental attributes, electric vehicles also have hedonic and symbolic attributes that are important to include in EV adoption research. Schuitema et al. (2013) described instrumental, hedonic and symbolic attributes influencing EV adoption, where the instrumental attributes are mediated by the hedonic and symbolic attributes.

Driscoll et al. (2013) concluded that environmental awareness plays a role, although the chance to purchase an EV is still low for the group of environmentally aware people. Other empirical studies have identified more explanatory factors for the uptake of EVs such as social norms, government interventions and the readiness of the charging infrastructure (Sang and Bekhet, 2015). Also Noppers et al. (2015) concluded that the symbolic attributes of electric vehicles should be stressed when promoting EV adoption. Cars have an important symbolic value and people can show who they are by the car they use. This stresses to not only concentrate on the car characteristics, but also on the characteristics of potential buyers. This implies as well that EV-adoption is not a purely individual decision, but people are influencing each other in which car to purchase. For example, Axsen and Kurani (2011) concluded that social interactions played an important role in the decision to purchase a PHEV.

In order to study people's willingness to pay for electric vehicles and the characteristics of these electric vehicles (such as range, charging time and lower fuel cost), several stated preference experiments have been conducted (e.g. Golob et al., 1993; Hidrue et al., 2011 & Daziano and Chiew, 2012). Hidrue et al. (2011) concluded that people were generally willing to pay a rather high premium for an EV with more beneficial characteristics regarding range and charging time than the ones currently on the market. Daziano and Chiew identified a need for generalized discrete choice models not only incorporating attributes that are important for electric vehicles, but also socio-cognitive characteristics that are connected to potential buyers. As examples, environmental awareness and knowledge about the benefits of low emission vehicles are mentioned. Besides econometrical studies concerning the likelihood to buy electric vehicles with some specific characteristics, there are also several studies (e.g. Peters and Dütschke, 2014; Lieven et al., 2011; Axsen et al., 2016) focussing on the characteristics of potential buyers and trying to find a subset of consumers that would be more likely to adopt electric vehicles.

Thus, besides the range and price of EVs, there seem to be socio-economic, behavioural and socio-cognitive attributes that highly influence EV adoption. However, in this study it is assumed that additional insight can be gained by perceiving behavioural change as a process consisting of several stages-of-change rather than a sudden change and to investigate which processes are already changing in the period before the behavioural change. For example, do people develop their assessment of EVs regarding the Total Cost of Ownership? Do people approaching EV-adoption get more insight into their own travel patterns and whether the EV is compatible with these travel patterns? Insight into this process can give reasons for the government to decide upon a package of appropriate interventions in order to stimulate the adoption of electric vehicles.

3. Electric vehicle adoption in Sweden

In this study, the adoption of EVs in the metropolitan area of Stockholm in Sweden (hereafter: Greater Stockholm) is investigated. At the time the survey was undertaken (September 2014), there were 178 battery electric vehicles and 156 plug-in hybrid electric vehicles that were privately owned in Greater Stockholm. On an average of 393 person cars per 1.000 inhabitants and around 2 million inhabitants in Greater Stockholm (Trafikanalys, 2015), the market share of electric vehicles is very low.

Like in many European countries, Sweden has a policy framework that provides benefits when purchasing environmentally friendly vehicles. Private vehicle owners can get a Super Environmental Car premium if they choose to buy a vehicle that emits less than 50 gram of carbon dioxide per kilometre and they get up to 40.000 SEK (which is approximately 4.000 EUR). However, whether the car is driving on alternative fuels such as ethanol, plug-in hybrid vehicles or battery electric vehicles does not play a role. Other benefits such as free parking or the permission to use bus lane are not provided in Sweden.

4. Theory and approach

In this chapter, the theoretical background of this study is explained. In the first paragraph, the concept of stage models and the Transtheoretical Model of Change are elaborated. In the second paragraph, the Protection Motivation Theory is explained and in the third paragraph, the use of those socio-psychological models in this study is described.

4.1 Stage models: The Transtheoretical Model of Change

The Transtheoretical Model of Change (TTM) is a socio-psychological model originally developed by Prochaska et al. (1991). This model describes behavioural change as a process rather than as an event. The model consists of four elements: (1) stage-of-change, (2) processes of change, (3) decisional balance and (4) self-efficacy. In the following paragraphs, each of these elements will be described.

Stage-of-change (1) is the central concept in the model. This concept describes the process of behavioural change. This process is started if the current behaviour is perceived to be sub-optimal, for whatever reason. People are assumed to go through five different stages:

1. *Pre-contemplation* where one is not considering changing behaviour and often not much aware of the negative sides of one's current behaviour
2. *Contemplation* where one is considering changing behaviour, but on a rather abstract level
3. *Preparation* where one is planning to change behaviour on a more concrete level
4. *Action* where one is actually changing behaviour
5. *Maintenance* where one is getting used to the new behaviour after experience with this new behaviour

There are certain processes of change (2) that are important, because they trigger or hamper going from one stage to the next stage. Awareness about the current behaviour being problematic for one self and the physical and social environment, reflecting about alternative behaviour and the attitudes towards the new behaviour as well as control about the situations that might trigger the problem behaviour are some of these processes (Prochaska et al., 1991).

The decisional balance (3) is assumed to change as a person moves along the stages-of-change and the attitudes towards the new behaviour are assumed to become more and more positive. Also, people are assumed to achieve progressively higher self-efficacy (4) to perform the new behaviour. Self-efficacy can be defined as the perceived ability to perform the new behaviour

(Bandura, 1977). This construct is comparable to the concept of Perceived Behavioural Control from the Theory of Planned Behaviour (Ajzen, 1991).

Some variations to the model have been made afterwards. For example, Bamberg (2013) distinguished four stages rather than five and did not distinguish action and maintenance. In this study, the socio-psychological constructs goal intention, behavioural intention and implementation intention were used as breaking points between the different stages-of-change. Goal intention implies the intention to obtain a certain goal. Behavioural intention means the intention to perform a specific behaviour, while implementation intention contains a very specific way of clarifying when and how exactly to perform the behaviour. The relationship between implementation intention and the actual behaviour is assumed to be stronger than between goal intention and the actual behaviour (Gollwitzer and Sheeran, 2006).

Stage models, such as the Transtheoretical Model of Change, have mostly been used for health interventions. The reason for this is the fact that the model provides ideas for policy makers that can make people go from one stage to another. The TTM has been applied to many health related behaviours such as smoking, using preservatives, eating fruit and vegetables and drinking alcohol (e.g. Evers et al., 2012).

A difference between those health-related behaviours and travel behaviour is that the negative effects of the current behaviour are mostly individual for health-related behaviours, while they are at least partially societal for travel behaviour. Nevertheless, an increasing amount of research about travel behaviour and the use of stage models has been published, and practitioners as well have started using TTM. For example, Forward (2014) used TTM in order to explore people's willingness to bike.

Klöckner (2014) investigated with the help of Bamberg's stage model how people evolve in the process towards electric vehicle use. Every second day, the respondents had to answer a short questionnaire which determined their stage-of-change on that specific day and provided them with a few questions in order to explore which elements could influence the stage-of-change for that specific person. Because of the fact that only five respondents actually bought an electric vehicle during the study period, and because of the fact that only a limited number of respondents switched from one stage to another, the scope of this research is however limited. Moreover, the survey focused on people that were interested to buy an EV. Nevertheless, the results showed that using stage models is getting a more common practice to investigate the transition between the current undesired behaviour and future behaviour, even in case the behavioural change concerns social dilemmas and in case a considerable investment has to be made in order to perform the new behaviour.

Stage models such as the Transtheoretical Model of Change have been used in a large body of research as a way to foster the decision making process of agents wanting to influence individual behaviour and is currently used by practitioners in both the health sector and the transport sector. It provides an easily understandable framework to describe behavioural changes. However, there is still discussion about the explanatory power of those stage models, such as the chance that a specific person which is in a certain stage-of-change moves to the next stage-of-change within a certain time frame. As in Klöckner (2014), it was observed that some people went back in stage, and other people went forward as time went by. Therefore, this study focuses on the characteristics (socio-economic, behavioural and socio-cognitive) that are correlated with being in a specific stage-of-change. Applying stage models with a relatively high number of current EV-users (both having used EVs for a short time and more experienced EV users) can provide more insight in the processes of behavioural change towards electric vehicle use.

4.2 The Protection Motivation Theory

According to the Protection Motivation Theory (PMT), people are likely to change current maladaptive behaviour as a result of weighing the threat of the current behaviour with the ability to cope with the new, alternative behaviour (Rogers, 1975). Bockarjova and Steg (2014) studied the adoption of EVs by using the Protection Motivation Theory and concluded that if the perceived severity of the threat caused by the current behaviour and the vulnerability for that threat are high and if people have high self-efficacy and response efficacy, the decision to adopt EVs is stimulated. Response efficacy can be defined as the degree in which the new behaviour can remove or neutralise the threats or consequences of the current behaviour (Rogers, 1975). Assuming that people have the ambition to change their behaviour due to the fact that their current behaviour has negative environmental effects, this model provides an appropriate framework for investigating behavioural change.

4.3 Approach used in this study

In this study, a combination of the Protection Motivation Theory and the Transtheoretical Model of Change is used (see Figure 1). These models have been chosen as a framework for study because they deal with both assumptions about why to change behaviour (following the Protection Motivation Theory) and how to change behaviour (following the Transtheoretical Model of Change). The combination of these theories seems to be appropriate as a framework for behavioural change. Certainly, overlaps with other socio-psychological theories such as the Theory of Planned Behaviour (Ajzen, 1991) can be found.

The framework for this study takes the following aspects into account:

1. *Threat appraisal* or the assessment of the risks and severity of the consequences of our current personal travel patterns
2. *Coping appraisal* or the assessment of the *self-efficacy* (are you able to use EVs for your travelling) and *response efficacy* of EVs (are EVs able to decrease the risks and severity of the consequences of our personal travel patterns)
3. *Decisional balance* (the personal *Pros* and *Cons* of EV use – instrumental, symbolic and hedonic)
4. Behavioural characteristics (current travel behaviour patterns, perceived energy saving at home)
5. Socio-economic characteristics as control variables

The analytical approach for this study consists of three steps:

1. First, the structure of the stages-of-change has been investigated, using hypothesis tests. For the different stages-of-change, it has been investigated whether the respondents score differently on the socio-cognitive variables threat appraisal, self-efficacy, response efficacy, Pros and Cons and knowledge about EVs.
2. After this, there is a second step consisting of regression models (MNL-models) that investigate the influence of behavioural and socio-economic characteristics that could mediate the influence of the socio-cognitive variables. In order to investigate the added value of including these socio-cognitive variables, one model with only behavioural and socio-economic characteristics has been estimated, as well as one model that also includes socio-cognitive variables.
3. Finally, a structural equation model (SEM) has been estimated. This model enables including indirect effects. In this study, the indirect effect between threat appraisal and stage-of-change through goal intention has been explored. The connection between threat appraisal (assessment of the environmental problems related to the current transport system) and stage-of-change towards EV-use might be mediated by goal intention (the intention to decrease one's transport related CO2-emissions.

5. Data collection

5.1 Survey design

For this study, which is part of a larger study, a two-stage survey has been conducted, where the respondents of the first stage have also participated in the second stage. In order to gain insight into the processes of change towards electric vehicle use and behavioural changes of changing to EVs, information has been collected about the stage-of-change, but also about attitudes towards the environment and the electric vehicle, knowledge, socio-economic variables and travel behaviour.

The hypotheses to be tested in this study are the following:

- H1: People who are more aware of the environmental problems of their current travel behaviour (threat appraisal) are on average in a further stage of behavioural change.
- H2: People who have a higher response efficacy are on average in a further stage of behavioural change
- H3: People who have a higher self-efficacy are on average in a further stage of behavioural change
- H4: People who are further in the process of behavioural change are more positive about the advantages of EV use and less negative about the disadvantages of EV use
- H5: People making use of different travel modes for their daily traveling are on average in a further stage of behavioural change

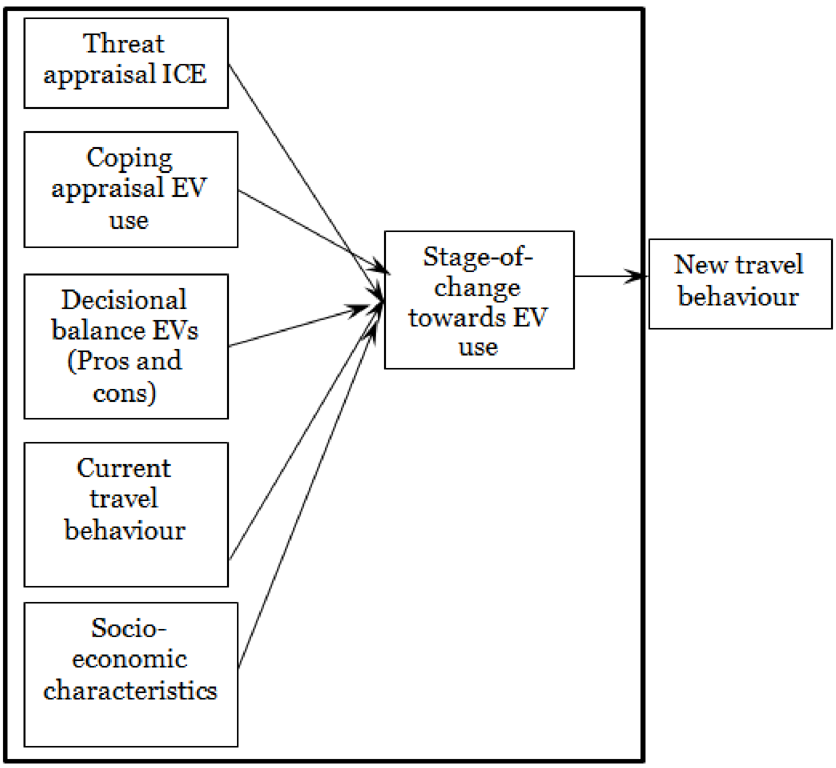

Figure 1. Conceptual framework influencing factors stage-of-change towards EV use

In order to get more information from electric vehicle users, the respondent recruitment consisted of a stratified random sample of active drivers in Greater Stockholm in general, with strata regarding gender, age, family situation and residential location in order to get data from all of the groups in these strata. However, a significant part of the participants consists of EV owners. EV owners have been oversampled in order to get a considerable number of participants in this group. The owners of all privately owned Battery Electric Vehicles and Plug-in Hybrid Electric Vehicles in Greater Stockholm have been contacted (status September 2014) and 121 EV or PHEV users have participated in the survey.

The five stages have been operationalized as follows in the survey design:

1. *Pre-contemplation*: not having considered to start using an electric vehicle
2. *Contemplation*: considering to start using an electric vehicle
3. *Preparation*: planning to start using an electric vehicle within the coming 6 months
4. *Action*: having started to use an electric vehicle, but not longer than 6 months
5. *Maintenance*: having used an electric vehicle for longer than 6 months

The respondents answer several less complex questions, such as whether they have thought about starting to use an electric vehicle, in order to categorize them in one of the five stages-of-change. Because of the fact that some of the electric vehicles in Stockholm are part of a car sharing system, it has been explicitly mentioned that not only households owning an EV, but all households that regularly use an EV can be categorized as being in the action or maintenance stage-of-change.

In order to get an overview about the socio-psychological determinants that might affect the stage-of-change, three series of Likert-scale questions have been constructed:

- The first series of questions deals with threat appraisal, the response efficacy of electric vehicles to decrease CO2-emissions, governmental and own responsibility to decrease CO2-emissions and the ambitions to decrease one's CO2-emissions and to decrease one's car use. This series of questions is complemented by a question about the perceived energy-effectiveness of different kinds of transport modes. These questions cover some constructs of the Protection Motivation Theory as applied in Bockarjova and Steg (2014).
- The second series of Likert-scale questions is about social support for EVs and the instrumental, hedonic and symbolic advantages or disadvantages of electric vehicles. This series of questions is complemented by some questions about the perceived purchase and operation cost of electric vehicles as compared to internal combustion engine vehicles.
- The third series of Likert-scale questions is about the practical issues that arise when starting to use an electric vehicle and were assumed to be especially important for those who are in the preparation stage-of-change. Questions about the charging infrastructure, mobility constraints, knowledge about government incentives and self-efficacy are included.

The survey has been set up for a larger study in order to make analyses from different perspectives, where socio-psychological constructs, the stage-of-change, revealed preference (the actual travel behaviour patterns) and stated adaptation experiments have been included.

5.2 Descriptive analyses

All respondents (N=294) are active drivers driving a car at least once a week. In case there are two or more active drivers in the household, two persons in the household were asked to participate in the survey. In Table 1, some descriptive statistics are mentioned. Of the 294 respondents, 115 are women (39%). 213 respondents live in a household without children and 200 live in a household with 2 adults. The absolute majority has either 1 (156 respondents) or 2 (104 respondents) cars in the household. The average age of the respondents is 50 years, where there were 29 respondents younger than 30 years old and 60 were above the age of 65 years. 62 % of the respondents have a university degree, 38 % live in a single family house and 40 % have a household income more than 800,000 SEK per year (approximately €80,000 per year). EV users tend to earn more (Chi-Square test, p=0.000) than non-EV users, which means that oversampling EV users implies oversampling higher income residents.

121 respondents make use of EVs. Half of these respondents make use of battery electric vehicles (BEVs) and the others use Plug-in Hybrid Electric vehicles (PHEVs). Seven respondents reported that they have a BEV as the only vehicle in the household, making BEVs mainly operating in multiple car households.

Compared to the average of the inhabitants of Greater Stockholm, the sample consists of a higher percentage of men, a higher percentage of households without children, a higher number of highly educated people (61 % versus 27 % in Greater Stockholm) and a higher number of respondents with a high household-income.

Table 1. Descriptive statistics

Variable	Unit	Values Stockholm	Values sample
Gender	women - number (percentage)	50%	39%
Cars in the household	0 – number (percentage)	unknown	1%
	1 - number (percentage)	unknown	52%
	2 - number (percentage)	unknown	35%
	3 or more- number (percentage)	unknown	12%
	cars per 1000 inhabitants	393	n.a.
Age	years – average	39 years	50 years
Age	30- - % of respondents	16%	8%
	65+ - % of respondents	15%	20%
Higher education	% of respondents having a university or university of applied sciences degree	27%	61%
Living in a single family house	% of respondents residing in a single family house	36%	38%
High income (above 800.000 SEK)	% of respondents	unknown	40%
Mean income per household (SEK)	SEK/year	514.181	unkown
Sample size			294

6. Connection between socio-cognitive variables and stages-of-change towards EV-use

According to the Transtheoretical Model of Change, self-efficacy related to the new behaviour will increase the more advanced someone is in the process of change. It is also assumed that the Pros of the new behaviour, in this case changing to electric vehicles, are becoming more important and the Cons are becoming less important.

In order to identify differences between people in different stages-of-change, one-way ANOVA has been used. ANOVA compares the mean of some explanatory variables for more than two independent groups. The null hypothesis is that the mean of the explanatory variable in question is the same for all groups, while the alternative hypothesis is that at least one of the groups has a different average for the independent variable.

The post-hoc Tukey test can be used to detect where the means are significantly different and is based on the mean difference between every combination of two groups.

For the analyses in this paragraph, a standardized summated rating scale has been used based on the seven-point Likert scale questions dealing with each of the constructs. Each construct has been measured using two to four Likert scale indicators.

6.1 Pros of electric vehicles

The attitudes towards instrumental, hedonic and symbolic aspects of electric vehicles are asked in a series of different Likert-scale items (Cronbach's alpha=0.750) that all point out positive aspects of electric vehicles.

Car drivers become more and more positive towards EVs the further they move along the process of behavioural change (see Figure 2). There are statistically significant differences in degree of positive attitudes towards EVs between people in different stages-of-change (ANOVA, p=0.000).

According to the Tukey post-hoc test, significant differences in positive attitudes were found between pre-contemplators and contemplators (p=0.000), between pre-contemplators and people in the preparation stage (p=0.000), action stage (p=0.000) and maintenance stage (p=0.000). Also, significant differences were found between the contemplators and people in the preparation stage (p=0.031), action stage (p=0.005) and maintenance stage (p=0.000). There was no significant difference between the preparation stage and the action (p=0.937) and maintenance (p=0.991) stage, nor between the action stage and the maintenance stage (p=0.257).

Car drivers become significantly more positive about the electric vehicle comparing pre-contemplation to contemplation and contemplation to the last three stages, but between the stages preparation, action and maintenance, the car drivers seem to be equally positive.

6.2 Cons of electric vehicles

Similarly, the respondents were asked to which degree they agreed with some negative aspects of electric vehicles, related to the higher perceived (upfront purchase) costs (Wu et al., 2015) and lack of knowledge about the charging infrastructure. However, the internal consistency of the answers to those questions was rather low (Cronbach's alpha=0.229). Compared to the Pros of EVs, here the contrary pattern was found: the negative aspects of electric vehicles became less pronounced for individuals associated with later stages of behavioural change (see Figure 2). There are statistically significant differences in degree of negative attitudes towards EVs between people in different stages-of-change (ANOVA, p=0.000).

According to the Tukey post-hoc test, significant differences in attitudes about negative aspects of EVs were found between pre-contemplators and people in the action stage (p=0.001) and between pre-contemplators and people in the maintenance stage (p=0.000). Also, significant differences were found between the contemplators and people in the action stage (p=0.001) and maintenance stage (p=0.000). There was no significant difference between the pre-contemplation stage and contemplation stage (p=0.947) nor preparation stage (p=0.767). Also, no significant difference was found between contemplators and people in the preparation stage (p=0.927), nor between the preparation stage and the action (p=0.602) and maintenance (p=0.215) stage, nor between the action stage and the maintenance stage (p=0.864).

Most pronounced are the differences between users and non-users. This means that there is a tendency to be more negative if you have no experience with EVs. The people in the preparation stage are, however, already becoming less negative towards the EV and are somewhere in between.

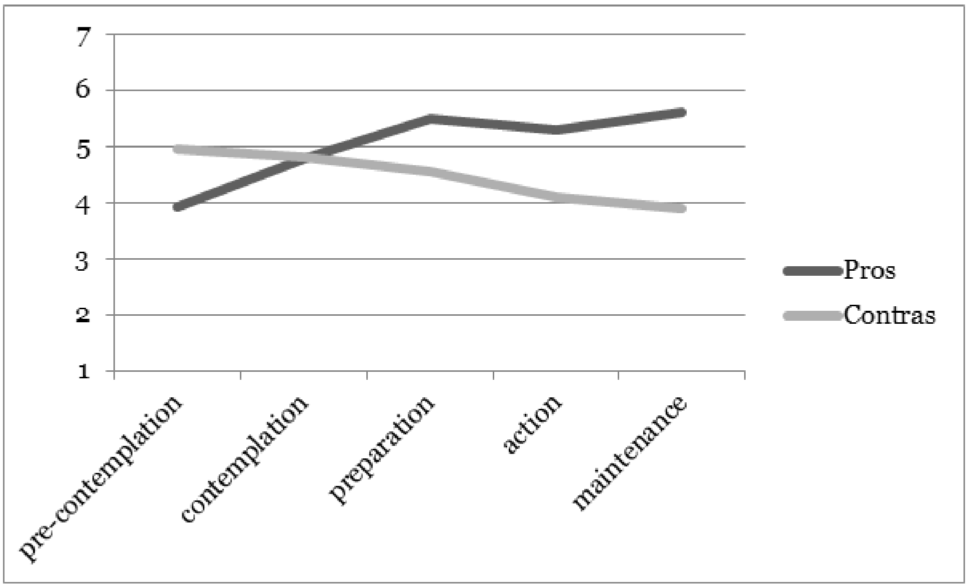

Figure 2. Pros and cons across the stages-of-change

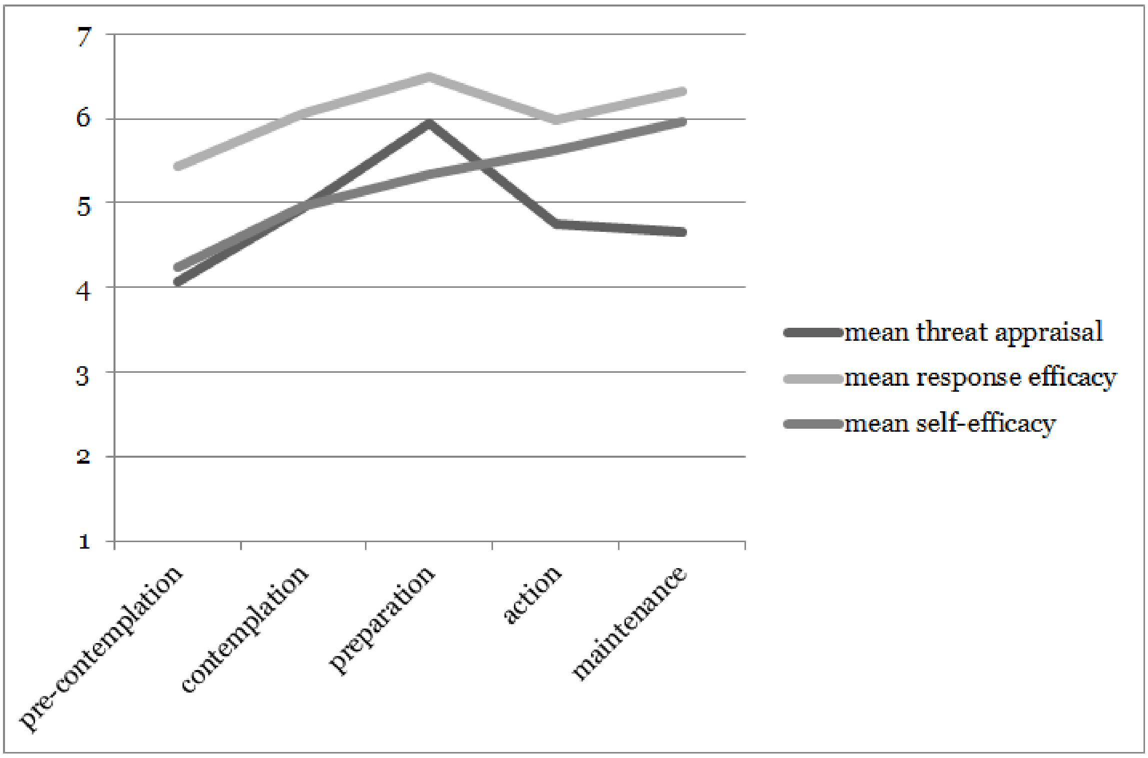

Figure 3. Threat appraisal, response efficacy and self-efficacy across the stages-of-change

6.3 Response efficacy

Following the Protection Motivation Theory, the motivation to change behaviour increases if the response efficacy is higher. The response efficacy means the degree in which the new behaviour takes away the problem that the current behaviour is causing. In this case response efficacy was formulated as the degree to which respondents think the use of EVs decreases global and local emissions and therefore the environmental and health effects of personal transport (Cronbach's alpha=0.836).

There are statistically significant differences in the degree of response efficacy between people in different stages-of-change (ANOVA, p=0.000).

According to the Tukey post-hoc test, significant differences in attitudes about the response efficacy of using EVs were found between pre-contemplators and contemplators (p=0.013), people in the preparation stage (p=0.028) and maintenance stage (p=0.000). There was no significant difference between the pre-contemplation stage and the action stage (p=0.142), nor between contemplators and people in the preparation stage (p=0.708), action stage (p=0.994) or maintenance stage (p=0.541). Also, no significant difference was found between people in the preparation stage and people in the action (p=0.616) and maintenance (p=0.990) stage, nor between the action stage and the maintenance stage (p=0.486).

The response efficacy of the electric vehicle does not follow a simple linear pattern (see Figure 3). From the pre-contemplation phase until the preparation phase, there is a clear increasing trend. However, the level of response efficacy in the action phase is lower than in the contemplation phase. This could mean that persons in the contemplation phase and preparation phase have ideas about the ability of electric vehicle to solve environmental problems that is too optimistic.

6.4 Self-efficacy

A construct that is part of both the Transtheoretical Model of Change and the Protection Motivation Theory is self-efficacy. Self-efficacy has been measured by four Likert-scale items (Cronbach's alpha=0.763), of which the average values have been analysed. Again, there are statistically significant differences in self-efficacy between people in different stages-of-change (ANOVA, p=0.000). The mean self-efficacy is always increasing from the one stage to the other (see Figure 3). Although this is a cross-sectional study, this implies that people in a further stage-of-change have a higher self-efficacy towards using EVs.

According to the Tukey post-hoc test, significant differences in attitudes about negative aspects of EVs were found between pre-contemplators and contemplators (p=0.004), people in the preparation stage (p=0.028), people in the action stage (p=0.000) and people in the maintenance stage (p=0.000). Also, significant differences were found between contemplators and people in the action (p=0.016) and maintenance stage (p=0.000). There was no significant difference between the contemplation stage and preparation stage (p=0.817). Also, no significant difference was found between the preparation stage and the action (p=0.944) and maintenance (p=0.424) stage, nor between the action stage and the maintenance stage (p=0.568).

As people start reflecting whether the electric vehicle is something for them, they may get more knowledge about electric vehicles and their characteristics, which could make them more confident about using electric vehicles. This result is in line with the perceived and actual knowledge about electric vehicles, which is also increasing from stage to stage in this study.

6.5 Threat appraisal

Threat appraisal, existing of the risk and the severity of the environmental problems of personal transport, has been investigated using Likert-scale items as well (Cronbach's alpha=0.810). According to the Protection Motivation Theory, the motivation to change behaviour will increase if the current behaviour is being seen as more problematic. Following TTM, it is assumed that the threats of the current transport system will be felt more for persons who are further in the process towards change to electric vehicle use.

An increasing trend has been identified between pre-contemplation, contemplation and preparation. However, current electric vehicle users score lower on threat appraisal (see Figure 3). This could be because of the fact that they do not consider themselves as equally polluting as ICEV users. There are differences between the stages that are statistically significant (ANOVA, p=0.000).

According to the Tukey post-hoc test, significant differences in threat appraisal were found between pre-contemplators and contemplators (p=0.002) as well as people in the preparation stage (p=0.000). Also, significant differences were found between people in the preparation stage compared to people in the action (p=0.046) and maintenance stages (p=0.017), although the threat appraisal in those latter stages is lower instead of higher than the previous stage, as was expected by our hypothesis. There was no significant difference between the pre-contemplation stage and action stage (p=0.112) nor maintenance stage (p=0.128). Also, no significant difference was found between contemplators and people in the preparation (p=0.096), action (p=0.933) and maintenance (p=0.659) stage, nor between the action stage and the maintenance stage (p=0.997).

7. Effects of socio-cognitive, behavioural and socio-economic variables on stage-of-change

The group of pre-contemplators is a specific group, because this group has not yet thought about changing towards using an EV and has the "furthest way to go". In the previous paragraph, it has been shown that pre-contemplators have a lower self-efficacy to use electric vehicles, are less motivated to change their behaviour because they consider the environmental problems related to personal transport as not as severe as the other respondents do. Regarding the attitudinal indicators, the group of pre-contemplators is always significantly distinct from the other groups. However, there might be different behavioural and socio-economic variables having an influence on who is likely to be in the pre-contemplation stage.

Multinomial logistic regression (MNL) models have been used for modelling which socio-cognitive, behavioural and socio-economic variables have an influence on being in a specific stage of change with pre-contemplation as a reference stage. Initially, stage-of-change was modelled using an ordinal logit model. Because of the fact that several (socio-cognitive) variables do not have a linear effect on stage-of-change, a multinomial logit model has been used instead of an ordinal logit model. The advantage of this method is that it provides a possibility to explore the non-linear effects on different stages-of-change. A disadvantage compared to the ordinal logit model is the fact that the dependent variable stage-of-change is a dependent variable with a clear ordinal character, as more advanced stages are closer to electric vehicle adoption. Therefore, the error terms of adjacent stages-of-change might be correlated (Small, 1985), which is a limitation of the chosen approach.

As explanatory variables, the variables age, income, gender, number of children in the household, number of adults in the household, number of cars in the household, the degree of planning one's future trips beforehand, the degree of taking measures to decrease energy use at home, threat appraisal, response efficacy, pro-EV attitudes, contra-EV attitudes, self-efficacy, type of housing and modal split have been used. The same composite variables based on standardized summated rating scales as in Section 5.1 have been used here again. The chosen approach has the advantage that the relevant theoretical constructs can be included as they have been operationalized in the survey that has been used for this study, as opposed to approaches using data-driven latent constructs. The first model including socio-cognitive variables is compared to a second model which does not take socio-cognitive variables into account.

The multinomial logistic regression model has the form:

$$P(stage\ i) = \frac{e^{V_{stage\ i}}}{\sum_i e^{V_{stage\ i}} {}^{V_{pre-contemplation}}}$$

where $V_{stage\ i} = \beta_0 + \beta_1 * x1 + \beta_2 * x2 + \cdots . + \beta_k * xk + \varepsilon_i,\ \varepsilon_i \sim Standard\ Gumbel$

The estimated utility $V_{stage\ i}$ of being in the stage i is estimated based on a number of coefficients and an intersect variable.

The Goodness-of-Fit of multinomial logistic regression modelling is assessed by McFadden's Rho-Squared, which is based on the level of information of the specified model as compared to a null model or an intercept only model. AIC can be used to take account for both the parsimony of the model and the information the model provides. The Chi-Square test and Deviance are used to compare the fit of the model with the real patterns in the data. Insignificant hypothesis tests with regard to those Chi-Square and Deviance statistics imply a good fit.

In order to assess the value of incorporating the attitudinal variables that have been described in 5.1, two multinomial logistic regression models have been fitted, namely one model with both socio-economical, behavioural and attitudinal variables (which is named model 1) and one model without attitudinal variables (model 2).

According to model 1, people in the pre-contemplation phase have significantly less knowledge about the EV, have a less positive attitude towards the advantages of EVs and consider the environmental and health problems of their current travel behaviour as less severe. They also use their car for a lower percentage of their total travel distance and have a lower income. Last but not least, pre-contemplators tend to be older (see Table 2)

By considering model 2 with only socio-economic and behavioural variables (see Table 3), McFadden's Rho-Square decreases from 0.480 to 0.182. In this model, only age, gender and modal split are statistically significant for more than one stage-of-change. Older people are more likely to be pre-contemplators, while people with a high income are less likely. In the model without the inclusion of socio-cognitive variables, women are more likely to be pre-contemplators rather than in the contemplation or maintenance stage as compared to men and people who use the car for a larger percentage of their distance travelled are likely to be in more advanced stages-of-change.

Based on the results of these two models, socio-cognitive variables seem to play a much larger role than socio-economic variables to explain whether someone is at least considering starting to use an EV. The prediction power of the model increases significantly (e.g. Rho squared increases from 0.182 to 0.480 and the Likelihood ratio test is statistically significant) when incorporating attitudinal variables (see Table 4).

Threat appraisal levels are generally lower for people in the pre-contemplation stage than for people in the contemplation, preparation and action stages. However, threat appraisal is a very general appraisal of the threats of the current transport system, and stage-of-change which is about a very specific behaviour. It could be that there is a variable in between that could be called goal intention. With the help of Structural Equation Models (SEM), covered in the next paragraph, those indirect effects have been measured.

Table 2. Output model 1: MNL-model stage-of-change with socio-cognitive variables

Parameter estimates	Contemplation		Preparation		Action		Maintenance	
	Estimate	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*
Intercept	-3.871	0.133	-17.948	0.046	-14.173	0.000	-15.998	0.000
Socio-economic variables								
Age	-0.051	0.020	-0.152	0.085	-0.055	0.054	-0.026	0.384
gender (men=ref)	-0.586	0.255	1.487	0.343	0.727	0.358	0.398	0.626
number of children (HH)	-0.019	0.958	1.907	0.079	-0.811	0.094	-0.020	0.966
number of adults (HH)	0.016	0.967	-3.087	0.023	0.235	0.638	0.611	0.212
number of cars (HH)	-1.002	0.035	-2.548	0.133	0.049	0.934	-0.204	0.731
Income	0.302	0.073	0.123	0.765	0.615	0.022	-0.122	0.613
single family house	0.393	0.557	1.614	0.393	-0.040	0.964	1.228	0.162
university/university of applied sciences	0.343	0.527	2.013	0.253	0.706	0.340	-0.115	0.881
Behavioural variables								
modal split	1.136	0.041	1.334	0.379	2.407	0.004	1.699	0.039
taking measures to decrease energy use at home	0.346	0.509	-1.953	0.199	-0.301	0.683	0.576	0.456
degree of planning future trips beforehand	-0.236	0.162	-0.522	0.275	-0.357	0.131	-0.435	0.085
Socio-cognitive variables								
knowledge	0.074	0.359	0.700	0.003	0.386	0.000	0.474	0.000
self-efficacy	0.244	0.415	0.049	0.950	0.656	0.117	0.817	0.062
response efficacy	0.142	0.563	0.888	0.241	-0.511	0.132	-0.438	0.220
pros EVs	1.124	0.003	2.361	0.005	1.953	0.000	2.413	0.000
cons EVs	-0.035	0.864	1.009	0.187	-0.377	0.186	-0.281	0.334
threat appraisal	0.402	0.100	1.104	0.069	0.598	0.052	0.302	0.334

Table 3. Output model 2: MNL-model stage-of-change without socio-cognitive variables

Parameter estimates	Contemplation		Preparation		Action		Maintenance	
	Estimate	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*
Intercept	3.504	0.020	6.654	0.052	-3.107	0.122	-3.039	0.104
Socio-economic variables								
Age	-0.037	0.026	-0.136	0.019	-0.035	0.082	0.003	0.874
gender (men=ref)	-0.658	0.104	-1.057	0.252	-0.678	0.173	-1.356	0.003
number of children (HH)	0.189	0.483	1.070	0.050	-0.308	0.360	0.440	0.131
number of adults (HH)	-0.039	0.904	-1.692	0.027	-0.204	0.603	0.091	0.796
number of cars (HH)	-0.931	0.009	-0.405	0.611	0.471	0.134	0.230	0.449
Income	0.204	0.128	0.224	0.487	0.663	0.002	0.195	0.217
single family house	-0.082	0.876	0.735	0.524	-0.027	0.963	0.929	0.077
university/university of applied sciences	0.160	0.705	1.215	0.212	0.602	0.248	0.001	0.998
Behavioural variables								
modal split	0.861	0.057	1.181	0.241	1.420	0.014	0.864	0.094
taking measures to decrease energy use at home	0.252	0.546	-0.392	0.670	-0.170	0.735	0.769	0.113
degree of planning future trips beforehand	-0.028	0.834	0.023	0.937	-0.015	0.927	0.010	0.95

Table 4. Goodness-of-Fit Model 1 and Model 2

	Model 1		**Model 2**	
Goodness-of-Fit	Value	p-value	Value	p-value
Pearson Chi-Square	324.449	0.000	123.190	0.000
AIC intercepts only	675.526		675.526	
AIC final	487.077	0.000	640.336	0.000
McFadden's Rho-Square	0.480		0.182	
Likelihood ratio test (model 1 vs model 2, df=6)	81.54	0.000		

8. Structural Equation Modelling: the indirect effect of Threat Appraisal

As a last step in the analysis, Structural Equation Modelling (SEM) is used. Structural Equation Modelling allows for the estimation of indirect effects and this is an advantage compared to regression modelling. This model makes it possible to estimate the indirect effect of environmental awareness on stage-of-change, which was not possible by using multinomial logit regression models. Structural Equation Models use several equations to model assumed relationships between exogenous and endogenous variables. In this case, maximum likelihood (ML) has been used as an estimation technique and the software package AMOS has been used. A disadvantage of the model is the fact that the endogenous variables should be normally distributed. The endogenous variables in this work are ordinal and thus not normally distributed. Therefore, the results of the models should be treated carefully.

Structural equation models with latent constructs are composed by a measurement model that links exogenous indicators to latent constructs, and structural models that link latent constructs or exogenous observed variables to one or more endogenous variables. In this study, these models can be described using the following matrix equations:

$$X = \Lambda_x \xi + \delta$$

$$Y = \Lambda_y \xi + \Gamma X + \varepsilon$$

with X a vector of observed exogenous variables (in this case indicators for socio-cognitive constructs, behavioural or socio-economic variables), ξ a vector of exogenous latent constructs (in this case threat appraisal, self-efficacy, response efficacy, Pros EV and knowledge about EVs), Λ_x a vector of parameters λ_x linking latent constructs to observed exogenous variables X, Y a vector of endogenous observed variables (goal intention and stage-of-change), Λ_y a vector of parameters λ_y linking endogenous observed variables to latent constructs ξ and Γ a vector of parameters γ linking exogenous observed variables X directly to the endogenous observed variables Y (in this case only stage-of-change). δ and ε are error terms. In Figure 4, a diagram with the structure of this SEM is provided.

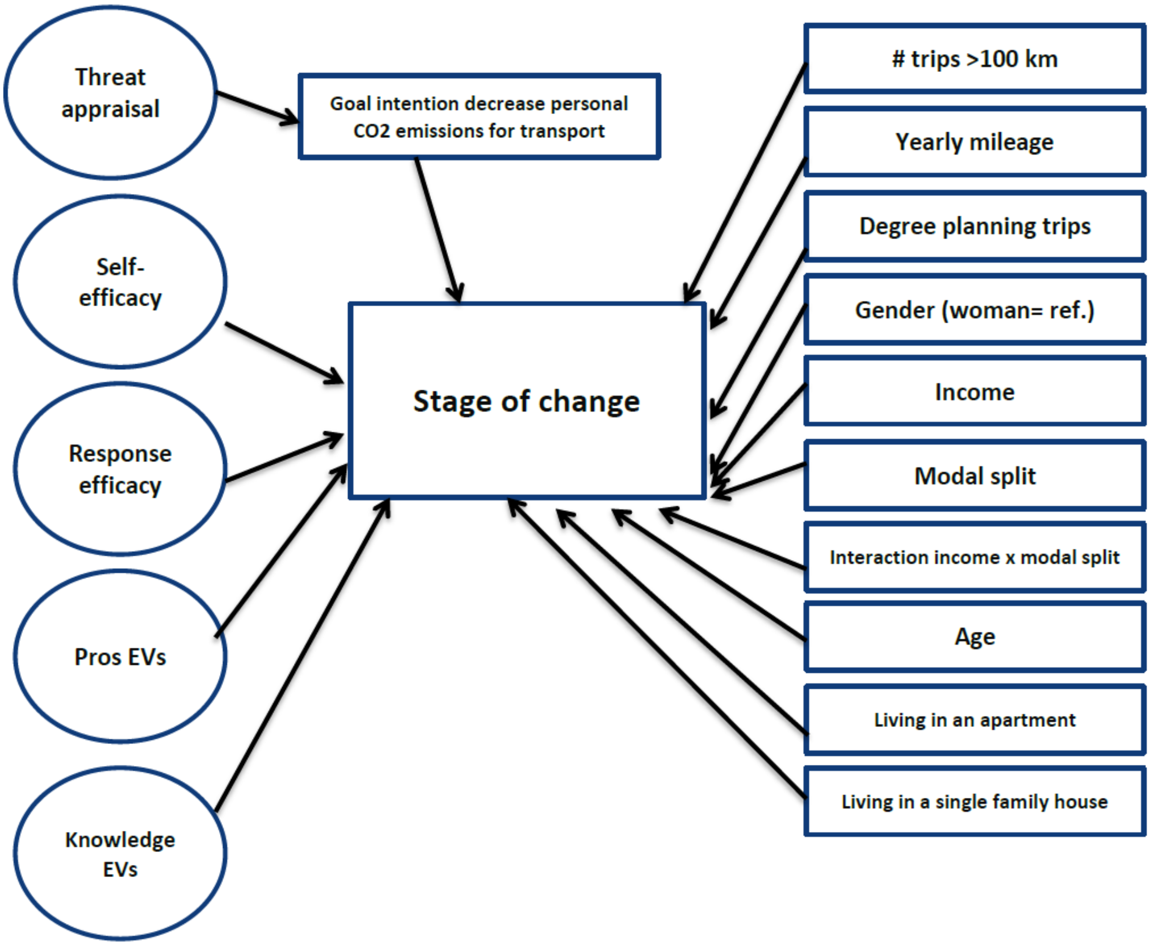

Figure 4. Diagram SEM stage-of-change

The model contains the factors threat appraisal, self-efficacy, response efficacy, Pros EVs and knowledge EVs. These factors have been measured using Likert-scale indicators. An overview of the used indicators for the socio-cognitive variables is visible in the overview of the estimates of the measurement equations (Table 5). Besides this, goal intention, and several behavioural and socio-economic variables assumed to have an influence on stage-of-change have been included in the model. An overview of the estimates of the structural equations is provided in Table 6.

As Goodness-of-Fit measures, the Chi-Square value divided by the degrees of freedom (measuring the deviance and relative fit, which should be below 3), the Comparative fit Index (CFI), measuring the relative fit and being between 0 and 1 and which should be above 0.80, the Root mean square error of approximation (RMSEA) which takes the information and the number of parameters into account and should be below 0.09, Akaike's Information Criterion (AIC) (to compare different models based on information and the parsimony of the model) and HOELTER (which gives the sample size under which the deviance is no longer statistically significant) are used.

A SEM has been conducted to test the combination of the Protection Motivation Theory and the Transtheoretical Model of Change as one network. In this setting, the influence of the indirect effect of threat appraisal on stage-of-change through goal intention can be tested. People with a higher ambition to decrease their CO2 emissions for transport are on average in a higher stage-of-change (see Table 7). Also, significant effects (alpha=0.10) are found between the positive attitudes towards EVs, knowledge about EVs, planning trips beforehand and response efficacy.

Regarding the degree of planning trips beforehand and the response efficacy, counter-intuitive results have been found. For response efficacy, this is because of an assessment of the EV that may seem to be too optimistic in the planning process, which is adjusted in the first months of EV use.

Table 5. Goodness-of-Fit SEM full model stage-of-change

Measure	*Model*	*Independence model*	*Saturated model*
χ^2	759.274	3962.405	0.000
p-value	0	0	
χ^2/DF	2.388	9.760	
CFI	0.876	0	1.000
AIC	991.274		868
RMSEA	0.069	0.173	
HOELTER	140	34	

Table 6. Estimates of the 17 measurement equations of the SEM

Threat appraisal		
Variable	*Estimate*	*p-value*
CO2 emissions will become a serious problem the coming 15 years	1.000	0.000
I am worried about the consequences of the high CO2 emissions	1.198	0.000
When driving I contribute to serious environmental and health problems	0.91	0.000
I want to decrease my CO2-emissions for transport	1.711	0.000
Self-efficacy		
Variable	*Estimate*	*p-value*
EV fit my transport needs	1	
Using an EV would limit my mobility	0.795	0.000
I would feel secure using an EV	0.844	0.000
I can do all travelling by using an EV	0.753	0.000
Response efficacy		
Variable	*Estimate*	*p-value*
Using EVs will significantly decrease my CO2 emissions	1	0.000
EV use will improve air quality	0.836	0.000
Pros EVs		
Variable	*Estimate*	*p-value*
It is cool to use an EV	1	0.000
EVs fit to my lifestyle	0.606	0.000
EVs have a higher status	0.659	0.000
My friends and family (would) support me to use EVs	0.689	0.000
Knowledge		
Variable	*Estimate*	*p-value*
I know about the benefits when buying an EV	1	0.000
Number of EV brands you know	1.566	0.000
I know much about EVs	1.313	0.000

This model gives a relatively good fit (see table 5). Although the absolute fit is not good (Chi-Square value of the model is statistically significant), the Chi-Square divided by the degrees of freedom is 2.388 which is well below 3. The comparative fit index is 0.876 which is relatively high. RMSEA is with 0.069 well below 0.09 and the HOELTER-value is 140, which is well above 75 but below 200, and much higher than the HOELTER value of the independence model (which is 34).

Table 7. Estimates of the structural equation of the SEM

Effects on stage-of-change

Variable	*Estimate*	*p-value*
I want to decrease my CO2-emissions for transport	0.105	0.043
Response efficacy	-0.284	0.000
Pros EVs	0.198	0.004
Knowledge	0.674	0.000
Planning trips beforehand	-0.068	0.061
How often long distance trips	0	0.258
Mileage per year	0	0.182
Modal split	-0.59	0.21
Income	-0.02	0.729
Interaction effect income-modal split	0.141	0.093
Gender (1=females)	-0.198	0.075
Age	0.005	0.186
Housing: single family home	0.26	0.088
Housing: apartment	0.075	0.616

Remarkably, no effect has been observed between modal split (the modal share of the car during the one-day travel diary) and stage-of-change, whereas this effect was visible in the ANOVA and MNL-models.

9. Discussion

The mean self-efficacy of people seems to steadily increase over the stages-of-change and the advantages of EVs are considered more and more important while the disadvantages are considered less and less important. As compared to a model with only socio-economic and behavioural aspects, attitudinal aspects increase the explanatory power of the model tremendously. The influence from socio-economic variables seems to be limited.

The results of the statistical analyses confirm the existence of a learning effect, where people that are in the process towards changing to EV use become more positive about EVs, get more knowledge and get a higher and higher self-efficacy to use them, even before they really have started using them. The socio-cognitive variables explain a larger part of the variability in the data than the socio-economic and the behavioural variables.

The percentage of distance travelled by car has a positive correlation with stage-of-change. This implies that active drivers that make use of more different means of transport are, on average, in earlier stages-of-change than active drivers that only use their car. It was assumed that multimodal urban transport patterns had a positive effect on the uptake of electric vehicles because of the fact that multimodal travellers are more used to plan their trip in advance and more flexible because they have more knowledge about using different travel modes.

There is an indirect effect of threat appraisal on stage-of-change through the intention to decrease one's CO2-emissions. The response efficacy has a negative effect on stage-of-change, which is on the first sight counter-intuitive. A possible explanation is however that people are getting higher and higher expectations about the environmental benefits of the electric vehicle before purchase, probably based on the information provided by manufacturers, but after purchase they have to face reality. In many cases, they think that the EV has a lower range than previously thought.

10. Conclusions and policy implications

Based on the analyses, there are strong indications for the presence of a learning process, in which the attitudes towards using electric vehicles change, the self-efficacy increases and this process confirms the structure of the Transtheoretical Model of Change as a description of behavioural change. Environmental concerns seem to play a less important role than the attitudes and self-efficacy which are more individual.

For policy makers, this may indicate that many people can be moved to stages further along by increasing the self-efficacy, increasing the knowledge about EVs and pointing out the relative advantages of using EVs. The socio-cognitive variables seem to be the most important and future policy measures should not only concentrate on providing material benefits but rather trying to increase self-efficacy and emphasize on influencing the perceived symbolic social and private benefits of EVs. Information campaigns about the available EVs, about the available charging infrastructure but also tools to get more insight into one's own travel patterns could be of help in order to increase the intrinsic motivation to start using EVs. On the other hand, many respondents indicated that they still need extrinsic motivation in the form of special benefits such as tax deductions, free parking or upfront subsidies. As long as the extrinsic motivation is stronger than the intrinsic motivation, the uptake of the EV will depend on the policy framework and need considerable amounts of resources to stimulate the EV and changing policy will mean abrupt changes in the uptake of EVs. In the Netherlands, for example, a large decline in the sales of EVs has been seen just after the abolishment of a package of EV policy measures (Het Parool, 2015).

The Transtheoretical Model of Change provides a framework to study processes of behavioural change that are not easily captured without breaking down behavioural change into different sub-steps. Nevertheless, it gives no guarantee that everyone follows all stages in the same pace and that the stages are followed up sequentially. It has a high value to describe processes, but the evidence to explain processes is mixed.

Because of the fact that we can speak about a social dilemma, it can be the case that the environmental concerns (the bad aspects of motorized personal transport) and the beneficial effects of the electric vehicle on the environment are not considered as crucial for the individual. The marginal effect of one car driver is not that large, and the perceived societal gains for improving the air quality by replacing one conventional vehicle by an electric vehicle are very limited. The personal gains and self-efficacy seem to have a larger influence. Therefore, there is a discrepancy between the reasons for government to stimulate adoption (environmental concerns) and the reasons for car drivers to adopt EVs (personal gains, personal losses and self-efficacy). This implies that, when promoting EVs, it may help to not focus too much on the social benefits of electric vehicles but rather emphasize on the personal benefits that EV users may have. At the same time, this implies that the following behaviour of EV users may not be the most desirable from an environmental point of view, because of the fact that the motivations of people to use EVs are not environmental awareness nor response efficacy. For example, if many people use EVs in order to increase their status, they have no strong incentive to limit their use of the car.

It is necessary to note here that the results have been analysed based on a sample which consists of a relatively large group of older respondents and respondents from higher income households.

Our sample also consists of an over-representation of EV users, which are a relatively affluent group of travellers. Thus, a generalization of trends would need extra care. The fact that current EV users are a rather specific and small population implies that they might have characteristics that future EV users will not have. When EVs become more common and EV-users will be a broader group than the group of early adopters, it will become possible to perform a study like this with a more representative sample.

In future research, the driving and charging behaviour of EV users will be analysed and the travel patterns of EV users and non-EV users will be compared (inter-person approach) in order to investigate whether there are significant differences in the travel patterns between those two groups of car drivers. If there are differences, this would mean that the uptake of the EV implies either a rebound-effect or a self-reinforcing effect on the distance travelled by car. If the distance travelled by car increases because of the deployment of EVs, a part of the beneficial effect of the introduction of the EV disappears. As the EV decreases energy use per kilometre and does not have any local emissions, there are benefits for the environment. However, the electric vehicle still uses a lot of space and if EVs are used more than conventional vehicles were used previously, the congestion costs may increase.

Another future research topic will be looking at the influence of socio-economic variables on the relations between socio-cognitive constructs and stage-of-change by comparing different structural equation models for groups that are more homogeneous with regard to for example residential location or income.

Acknowledgement

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